FCC Washington, D.C. 20554 July 1, 2003

Reference: FCC Proceeding 03-104 (Notice of Inquiry on Broadband Powerline Communications)

To whom it may concern:

I am writing to express my reservations about the deployment of so-called broadband over power-line technology in the United States and to address some of the specific points of inquiry contained in NOI 03-104. Although this technology is being sold as being a "wireline" system, even a cursory examination of the transmission medium reveals that it would be more aptly described as a wireless/wireline hybrid. The reason for this is simple – the nation's existing power transmission infrastructure was not designed with transmission of high frequency signals in mind. As a result, BPL networks have the potential to cause severe interference to licensed radio services operating in the short-wave radio spectrum. Also when weighing the pros and cons of BPL deployment, one should consider that the short-wave radio spectrum is unique in the physical world. Of the useable radio spectrum (10 KHz to 300 GHz), only a small portion of this spectrum in the range from approximately 2 to 30 MHz refracts signals reliably from the ionospheric layers such that over-the-horizon communications without need for space based satellite assets or other signal repeaters is practical. This characteristic makes the HF spectrum uniquely and ideally suited for the rapid-response emergency communications services that are needed when fixed commercial communications infrastructure is destroyed in large-scale disasters. Whereas the short-wave spectrum represents less than .01% of the useable radio spectrum, it represents nearly 100% of the proposed BPL spectrum. When you couple this with the fact that BPL technology utilizes a "dirty" transmission medium which cannot be classified as completely wireline, nor completely wireless, it is clear that the commission needs to conduct a careful assessment to ensure that BPL technology is compatible with licensed spectrum users. In order to ensure that this assessment of BPL technology is conducted impartially using sound scientific and technical methods, it is imperative that this technical assessment include input and review by all concerned stakeholders, not just representatives from the BPL industry.

- *How should the Part 15 rules be tailored both to ensure protection against harmful interference to radio services and to avoid adversely impacting the development and deployment of this nascent technology?*

I am concerned that this is not physically possible. Ed Hare from the American Radio Relay League has demonstrated both analytically and through measurements made at BPL field trial sites, that BPL systems operating at or near the current part 15 limitations for radiated emissions can easily produce interference levels to nearby Amateur Radio stations that are 60 dB above ambient noise levels [1]. A survey of BPL professional technical literature indicates that current regulatory limits are a big concern for BPL system architects [2]. This gives every indication that BPL systems need to run "hot" in order to provide decent quality of service [4]. If this is indeed the case, then the commission needs to think long and hard about how it intends to deal with interference issues. While some selective notching in order to protect effected portions of the HF spectrum is technically feasible; it appears that 30dB is a practical limit [3]. If this is the case, then it would seem that in order to achieve coexistence, either the BPL operator will have to reduce his signal levels to an unacceptably low limit where quality of service is poor, or the affected radio service (in the case of the example given above - the Amateur Radio Service) will be forced to live with interference levels that are upwards of 30 dB above current ambient levels!! The latter would be an unmitigated disaster for licensed radio services like the Amateur Radio Service. This is why it is very important that during field trials EMI levels from BPL systems be measured at the same time the BPL system is actually delivering a high data throughput that is consistent with BPL's claimed capability for quality of service. Otherwise, there will be great temptation on the part of the BPL test operators to demonstrate quality of service at very high signal levels where throughput is high and then demonstrate EMI compatibility at very low signal levels where data throughput may be unacceptably low in terms of quality of service.

Current part 15 regulations state that equipment operating under part 15 rules must meet absolute limits for radiated field strength AND that the equipment must not cause harmful interference to licensed radio services. For part 15 devices that emit narrow-band discrete spectral lines, it is oftentimes sufficient to comply with the part 15 absolute limits for radiated field strength. This is due to the low probability that any of the small number of discrete signals emitted by the part 15 device will actually fall on a busy communications channel thereby causing harmful interference to an incumbent user. With BPL technologies, this will not be the case. In order to deliver high data rates, BPL technology needs to "fill" as much allocated spectrum as possible with a quasi-continuous power spectrum. In effect, there will be no place to hide from BPL signals. Whereas licensed users such as Amateur Radio operators can tune their transceivers away from the kind of discrete interference produced by traditional part 15 emitters, there will be no place to go when they are faced with the continuous power spectrum emitted by BPL.

What is also troubling about BPL is that it will represent a distributed source of interference. Whereas traditional part 15 emitters look like discrete point sources, BPL systems will look like a continuous distribution of interference sources. In much the same way that a phased array produces a cumulative signal that is much greater in strength than that of any individual element, the combined noise power from an entire BPL system may produce a cumulative interference affect that is much greater than that suggested by any single source operating at the prescribed part 15 limits. This will be especially true when approaching periods of maximum sunspot activity where high frequency signals in the upper range of the HF spectrum are known to propagate very efficiently over great distances. This is also the part of the spectrum where medium voltage power lines will exhibit the greatest signal leakage.

From a regulatory standpoint, if BPL is allowed to deploy under current (or even less stringent) part 15 regulations, the commission needs to be prepared to face situations where licensed spectrum users will be experiencing broadband interference levels that are 30 to 60 dB greater than their ambient noise level. Since this is clearly harmful interference, the commission needs to think about how it will act in order to protect the incumbent user suffering from such harmful interference? Shutting down Internet service to hundreds of consumers would not be in the public interest, nor would failing to protect incumbent users. Before BPL is allowed to deploy, the BPL industry needs to demonstrate that it has a technically and economically feasible plan for dealing with these situations that the physics dictate WILL OCCUR.

- *Should the Part 15 rules specify both radiated emission limits and conducted emission limits for BPL systems, or would one type of limits be sufficient to control interference from both low speed and high speed BPL? Since all carrier current systems inject RF signals into the power line for communication purposes, would conducted emission limits be more appropriate to protect authorized radio services?*

Since the radiation characteristics of a BPL plant will quite likely vary greatly from one location to another, it would seem more appropriate to specify the part 15 rules in terms of actual radiated emissions. If emission limits are specified only in terms of conducted emissions, then the rules may be overly restrictive in situations where the transmission lines in a particular BPL plant exhibit low levels of radiation leakage. Conversely, if a particular BPL plant has very poor shielding characteristics, then that same fixed conducted emission limit, would probably result in excess levels of radiated emissions. An upper limit on conducted emissions may be useful in the sense that it would place a sensible cap on the power levels that BPL modems are capable of delivering, but the variability of the transmission media will still require limitations on radiated emissions in order to protect authorized radio services.

- *<u>Measurement methods</u>. We seek comment on measurement methods for all types of carrier current systems, including new high-speed Access and In-House BPL devices. Because existing carrier current systems use the power line wiring inside a building to transfer information and data, the radiated emissions from RF energy conducted onto the power lines*

tend to vary from location to location, based on the installation's AC wiring and the loading placed on that wiring. In effect, since the installation's wiring functions as an antenna, that wiring becomes part of the system to be evaluated. As such, measurements to demonstrate compliance with the rules are not normally made at a standard open area test site, because the measurement of each system is unique to its location.

This demonstrates one of the great problems with BPL. Since the bulk of the radiation from these systems will originate from the actual transmission lines, measurements made on modems, repeaters, and other line equipment will be of limited value. While it may be possible to develop a standard test environment for line equipment using a representative standard medium voltage transmission line, this will not necessarily guarantee compliance with part 15 rules when the equipment is deployed. Compliance needs to be determined at the system level. A good model for this kind of system measurement would be the cumulative leakage index (CLI) used to evaluate cable television systems for regulatory compliance. Of course, it is hard to imagine even the best BPL system coming close in terms of radiated emissions to a well-maintained CATV plant, which uses 100% shielded coaxial cables. That is pure fantasy.

While "clean" wireline technologies such as cable television and DSL can cause interference to licensed radio stations such as those operating in the Amateur Radio service. These sorts of problems are often attributed to improper installations (loose connectors, etc) and are usually resolved quite easily. The inherent shielding effectiveness of coaxial cable and twisted pair transmission lines provide a natural barrier between wireless services such as the Amateur Radio service and wireline services which share the same spectrum and reside in close physical proximity. With respect to BPL technology the inherent irregularity of the transmission medium removes this natural barrier. At RF frequencies, the power line transmission medium is neither transmission line, nor antenna. It is in fact both transmission line and antenna! Anyone who has pulled AC wire through a house or installed 3-way lighting systems will recognize the inherent irregularity of this medium. While the MV transmission medium slated for use in access BPL more closely represents a high frequency transmission line, it also represents a larger radiating aperture than the home wiring that comprises the transmission medium for In-house BPL. A simple modeling exercise using a Numerical Electromagnetics Code (NEC) modeling program indicates that a 100 meter long parallel transmission line with 24" wire spacing (typical for a medium voltage power line) would exhibit a peak radiation gain of around –17.5 dBi at 14 MHz [5]. While this is not a great antenna, it is not a bad one either. In fact many commercial airliners and military aircraft utilize electrically short blade antennas with similar gain performance for air-to-air and air-to-ground communications. And we should be so lucky if all access BPL transmission lines were as ideal as the one used in the aforementioned modeling exercise. Contrast this with foil shielded coaxial drop cables and hard-line trunks used in CATV plants where shielding effectiveness is typically well in excess of 100dB.

Another point of fact that seems to fly in the face of BPL technology is all of the power-line filtering that is found in modern electronic equipment. Traditionally electronic equipment which is designed to be powered from household 110 and 220 V AC mains is outfitted with filtering on the AC power input line in order to meet stringent regulatory requirements for conducted and radiated emissions. In many cases, a RF low-pass filter is integrated with the "IEC" AC line connector of a consumer electronics device in order to reduce conducted emissions. In-house BPL technology seems to be a reversal of this philosophy. Instead of installing filtering to rid electronic equipment of conducted and radiated emissions, with In-house BPL, conducted emissions are intentionally added to the AC power system rather than removed. This seems on its face to be a kind of regulatory schizophrenia. And ironically, the point of introduction of this RF energy will generally be in close proximity to a home computer, which is probably one of the most heavily filtered part 15 devices in a typical household.

Radiated Susceptibility of BPL Systems

While much attention has been given to the problem of radiated emissions from BPL systems, little has been said with respect to radiated susceptibility. The nature of BPL line equipment will make it particularly vulnerable to this sort of problem. In a highly competitive consumer market, BPL modems and other line equipment will be naturally driven to the lowest price point. This will necessitate the use of inexpensive digitizers that will have limited dynamic range (e.g. fewer bits). Since BPL is a broadband technology that is in essence co-channeled with incumbent users such as Amateur Radio stations, analog filtering techniques will not be practical or cost effective. This begs the question of how BPL modems will perform when in close proximity to the high-power transmitters of incumbent HF spectrum users such as Amateur Radio stations? Without the use of expensive analog band-reject filters, or expensive high-speed high-resolution A-to-D converters, it will be very unlikely that BPL modems will have the dynamic range necessary to operate in the presence of strong nearby signals. By virtue of the reciprocity principle, leaky medium voltage powerlines, which radiate at or near part 15 limits, will suffer from strong pickup of HF signals from nearby high-power transmitters. Since Amateur Radio stations are typically located in residential neighborhoods in close proximity to medium voltage powerlines, BPL modems will be particularly susceptible to overload by Amateur Radio stations. Calculations by Ed Hare at the American Radio Relay League indicate that an Amateur Radio station operating at or near part 97 limits for transmit power will be capable of generating field strengths in excess of 200 Volts/meter at nearby power lines [1]. Given the high characteristic impedance of medium voltage transmission lines and their relatively poor shielding characteristics, this will almost certainly result in very large signals impinging on the front-ends of BPL modems. Without the use superhetrodyne techniques with highly selective analog IF filters, very high dynamic range digitizers, or expensive analog band-reject filters, BPL modems will not be capable of rejecting these strong signals. Thus, the radiated susceptibility issue will quite likely place another regulatory burden on the commission where it will have to arbitrate the incompatibility of BPL technology with incumbent spectrum users.

Impact on the Amateur Radio Service

While BPL has the potential to negatively impact most if not all of the licensed radio services operating in the HF and lower VHF spectrum, I am especially concerned about the impact it will have on the Amateur Radio Service. Since Amateur Radio stations are generally operated by private individuals, they are most often located at private residences where they are likely to be in close proximity (less than 100') to overhead medium voltage powerlines. It is for this reason that Amateur Radio stations will be particularly vulnerable to interference from BPL systems. As stated previously, calculations and measurements by Ed Hare at the ARRL indicate that BPL systems operating at or near part 15 limits for radiated emissions can produce interference levels to nearby amateur radio stations that are 60 dB above ambient levels [1]. Since most Amateur Radio communications on HF frequencies involve relatively weak signals, these kinds of interference levels would render the affected Amateur Radio stations virtually useless. This I believe will have an overall chilling effect on the Amateur Radio Service. While some would like to believe that Amateur Radio operator participation in the field of public service and emergency communications activities springs entirely from pure altruism, I would argue otherwise. Amateur Radio operators, like other human beings, give of themselves in exchange for some reward. In the case of professional first responders, they are paid salaries. For Amateur Radio operators, we gladly give of our time and energy in the form of public service and emergency services in exchange for the privilege to conduct our operating activities and experiments, as these are things that we enjoy. With the nations population increasingly concentrated in urban areas, zoning regulations and private deed covenants have made it increasingly more difficult to erect effective HF antennas for operation in the Amateur Radio Service. With all of the additional interference that will likely result, I am concerned that BPL deployment will deal a deathblow to the Amateur Radio Service from which it will be hard pressed to recover. What incentive will

people have to spend hard earned money to establish Amateur HF stations if there is nothing for them to listen to except S9 + 10dB broadband interference.

Economic Considerations

BPL proponents cite their technology as an economically viable method of delivering low-cost high-speed Internet access to underserved rural areas. They argue that their technology will provide low fixed costs due to its use of existing powerline infrastructure. I would argue that this is only partially true. Because of high radiation and mismatch losses, access BPL will require repeaters at regular intervals much like a CATV plant requires RF trunk amplifiers every 1500 to 2000 feet. As subscriber density drops (as in rural areas), the cost of this line equipment and the associated maintenance costs will be distributed over fewer and fewer customers. Dirty insulators and other faulty pole equipment will require regular maintenance in order to minimize high levels of electrical discharge noise. Since power line companies are known to have a poor track record in this area, BPL field trials need to address how these types of problems will effect cost and quality of service (e.g. how will the modulation scheme, coding, and MAC used by BPL perform when subject to continuous discharge noise from leaky pole insulators).

Given the inherent regulatory challenges that will come with this technology, before we let this genie out of the bottle BPL proponents need to do more than just say that their technology will provide low-cost service to rural America, they need to demonstrate it with hard economic analysis. Other true wireless technologies that can serve rural America and underserved urban areas already exist. LMDS, MMDS, and satellite technologies can all deliver cost effective broadband service without the inherent interference problems that are associated with BPL. As evidenced by the deregulation of our country's electrical power industry, the cost benefits brought about by increased competition oftentimes come at the expense of quality of service and long-term investment in infrastructure. BPL is at a best a bridge technology that may well delay, not hasten, the inevitability of fiber to the home and the successful emergence of true broadband wireless technologies into the economic mainstream.

Summary

While I commend the commissioners for their enthusiastic pursuit of new technologies that could serve the public interest, I would caution them not to let this zeal for the public good overshadow rigorous scientific evaluation of this new and potentially troublesome technology. In his remarks at the end of NOI 03-104, Commissioner Adelstein made reference to "unsupported claims" of potential interference from BPL to licensed radio services. I would likewise caution Commissioner Adelstein against accepting "unsupported claims" by BPL proponents regarding the compatibility of BPL with licensed radio services. A survey of BPL professional technical literature suggests that BPL proponents are engaged in much wishful thinking with regard to RFI compatibility issues [6]. Because BPL technology utilizes a hybrid transmission medium that is part wireless and part wireline it will be subject to a host of potential spectrum management and regulatory challenges. These issues need to be carefully examined before we all receive another painful lesson on the law of unintended consequences.

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